

Chapter 3
ESTIMATION OF NEARSHORE WAVES

EM 1110-2-1100
(Part II)
30 April 2002

Table of Contents

	Page
II-3-1. Introduction	II-3-1
<i>a. Background</i>	II-3-1
<i>b. Practical limitations</i>	II-3-1
<i>c. Importance of water level</i>	II-3-2
<i>d. Role of gauging</i>	II-3-3
<i>e. Physical modeling</i>	II-3-3
II-3-2. Principles of Wave Transformation	II-3-4
<i>a. Introduction</i>	II-3-4
<i>b. Wave transformation equation</i>	II-3-4
<i>c. Types of wave transformation</i>	II-3-5
II-3-3. Refraction and Shoaling	II-3-6
<i>a. Wave rays</i>	II-3-6
<i>b. Straight and parallel contours</i>	II-3-7
<i>c. Realistic bathymetry</i>	II-3-11
<i>d. Problems in ray approach</i>	II-3-15
<i>e. Wave diffraction</i>	II-3-16
<i>f. Reflection</i>	II-3-16
<i>g. Refraction and shoaling of wave spectra</i>	II-3-17
<i>h. Alternate formulations</i>	II-3-17
(1) Mild slope equation	II-3-17
(2) Boussinesq equations	II-3-17
II-3-4. Transformation of Irregular Waves	II-3-18
II-3-5. Advanced Propagation Methods	II-3-19
<i>a. Introduction</i>	II-3-19
<i>b. RCPWAVE</i>	II-3-20
(1) Introduction	II-3-20
(2) Examples of RCPWAVE results	II-3-21
(3) Data requirements for RCPWAVE	II-3-24
<i>c. REF/DIF</i>	II-3-24
(1) Introduction	II-3-24
(2) Wave breaking	II-3-25
(3) Wave damping mechanisms	II-3-25
(4) Wave nonlinearity	II-3-25
(5) Numerical noise filter	II-3-25
(6) Examples of REF/DIF1 results laboratory verification	II-3-26
(7) Data requirements for REF/DIF	II-3-26
<i>d. STWAVE</i>	II-3-26

(1) Introduction	II-3-26
(2) Examples of STWAVE results	II-3-29
(a) Spectral versus monochromatic calculations	II-3-29
(b) Effects of coupled source terms	II-3-29
(c) Wind effects	II-3-29
(3) Data requirements for STWAVE	II-3-30
e. <i>Limitations</i>	II-3-30
II-3-6. Guidance for Performing Wave Transformation Studies	II-3-31
a. <i>Introduction</i>	II-3-31
b. <i>Problem formulation</i>	II-3-32
c. <i>Site analysis</i>	II-3-32
d. <i>Selection of input data site</i>	II-3-33
e. <i>Selection of wave transformation method</i>	II-3-33
f. <i>Calibration/verification</i>	II-3-33
g. <i>Post-processing</i>	II-3-34
II-3-7. References	II-3-34
II-3-8. Definitions of Symbols	II-3-40
II-3-9. Acknowledgments	II-3-41

List of Tables

	Page
Table II-3-1. Example Problem II-3-1 Refraction and Shoaling Results	II-3-14
Table II-3-2. Guidance for Selection of Wave Transformation Methods	II-3-33

List of Figures

	Page
Figure II-3-1. Waves propagating through shallow water influenced by the underlying bathymetry and currents	II-3-2
Figure II-3-2. Amplification of wave height behind a shoal for waves with different spreads of energy in frequency and direction	II-3-3
Figure II-3-3. Straight shore with all depth contours evenly spaced and parallel to the shoreline	II-3-7
Figure II-3-4. Idealized plots of wave rays	II-3-8
Figure II-3-5. Wave-height variation along a wave ray	II-3-10
Figure II-3-6. Solution nomogram	II-3-12
Figure II-3-7. Highly regular bathymetry but undulatory contours	II-3-16
Figure II-3-8. Typical RCPWAVE application, bathymetry	II-3-22
Figure II-3-9. Typical RCPWAVE application, wave height	II-3-23
Figure II-3-10. Bathymetry input to REF/DIF1 for a simulation of wave propagations at Revere Beach, MA	II-3-27
Figure II-3-11. Wave heights calculated by REF/DIF 1	II-3-28
Figure II-3-12. Spectral model results compared to laboratory measurements for broad directional spectrum	II-3-30
Figure II-3-13. STWAVE results for a 1:30 sloping beach	II-3-31
Figure II-3-14. STWAVE results for CHL's Field Research Facility at Duck, NC	II-3-32

Chapter II-3

Estimation of Nearshore Waves

II-3-1. Introduction

a. Background.

(1) Coastal engineering considers problems near the shoreline normally in water depths of less than 20 m. Project designs usually require knowledge of the wave field over an area of 1-10 km² in which the depth may vary significantly. Additionally, study of shoreline change and beach protection frequently requires analysis of coastal processes over entire littoral cells, which may span 10-100 km in length. Wave data are generally not available at the site or depths required. Often a coastal engineer will find that data have been collected or hindcast at sites offshore in deeper water or nearby in similar water depths. This chapter provides procedures for transforming waves from offshore or nearby locations to nearshore locations needed by the engineer.

(2) Understanding the processes that affect coastal waves is essential to coastal engineering. Waves propagating through shallow water are strongly influenced by the underlying bathymetry and currents (Figure II-3-1). A sloping or undulating bottom, or a bottom characterized by shoals or underwater canyons, can cause large changes in wave height and direction of travel. Shoals can focus waves, in some cases more than doubling wave height behind the shoal. Other bathymetric features can reduce wave heights. The magnitude of these changes is particularly sensitive to wave period and direction and how the wave energy is spread in frequency and direction (Figure II-3-2). In addition, wave interaction with the bottom can cause wave attenuation. The influence of bathymetry on local wave conditions cannot be overstated as a critical factor in coastal engineering design.

(3) Wave height is often the most significant factor influencing a project. Designing with a wave height that is overly conservative can greatly increase the cost of a project and may make it uneconomical. Conversely, underestimating wave height could result in catastrophic failure of a project or significant maintenance costs. Approaches for transforming waves are numerous and differ in complexity and accuracy. Consequently transformation studies require careful analysis. They are but one part of selecting project design criteria, which will be treated in Part II-9.

(4) Wave transformation across irregular bathymetry is complex. Simplifying assumptions admit valid and useful approximations for estimating nearshore waves. After this introduction, a basic principles section provides an overview of the theoretical basis for wave transformation analyses, followed by development of a simple method for refraction and shoaling estimates. Transformation of irregular waves is then discussed. Next, advanced wave transformation models currently used by the Corps of Engineers are discussed. A final section provides guidance on selecting the approach used in calculating wave transformation. This chapter is primarily directed at open coast wave problems excluding structures such as breakwaters or jetties. Analyses involving structures are provided in Part II-7.

b. Practical limitations.

(1) The purpose of this chapter is to provide methods for estimating waves at one site given information at another. The assumption made is that *the wave information used as input to the analysis is characteristic of the waves that would propagate to the site*. In each case, the engineer should assure that there is no limitation of fetch, sheltering of waves, or oddness of bathymetry that would make selection of the input site inappropriate.